Centerline Slot Implementation

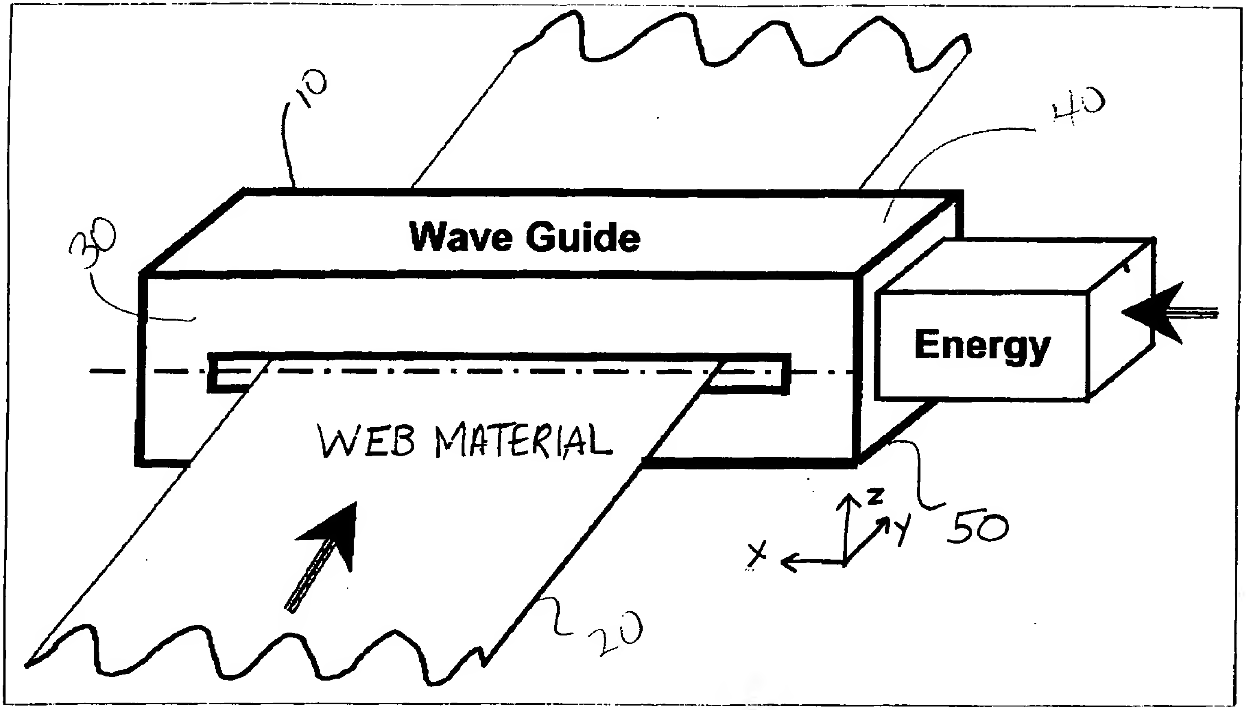


Fig. 1 PRIOR ART

Non-Centerline Slot

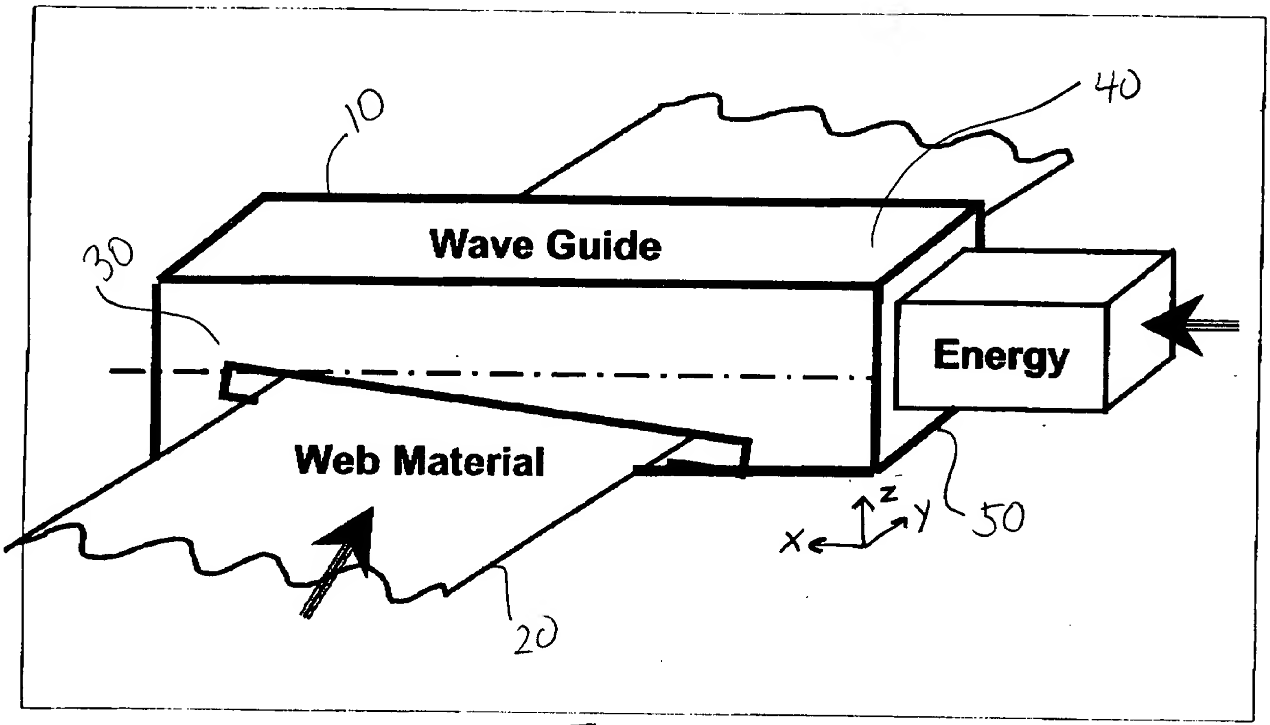
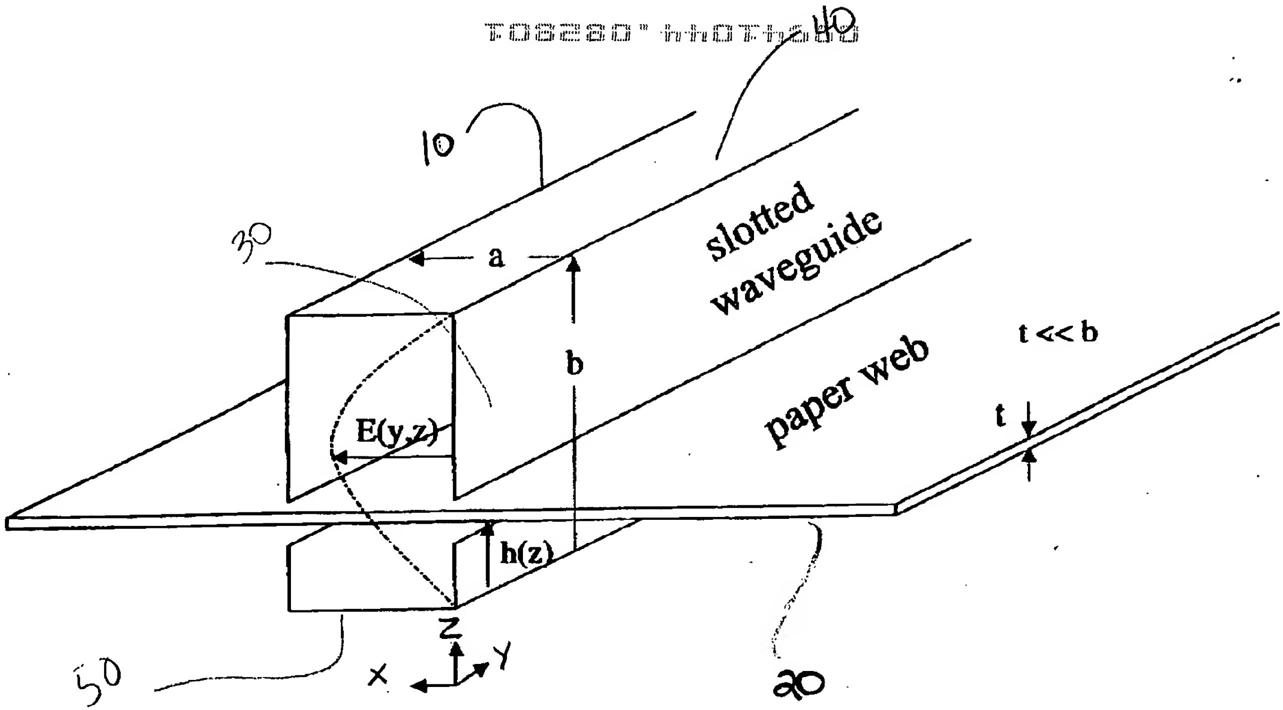
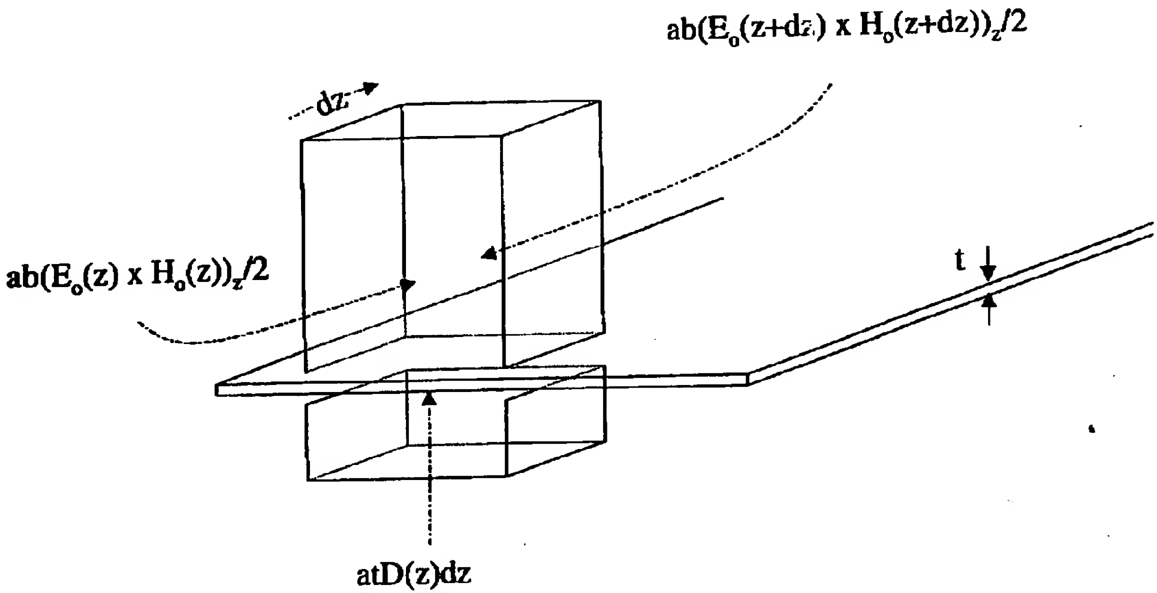


Fig 2 PRIOR ART



Parameters for Paper Drying in a Waveguide

Figure 3



Schematic for energy balance on an infinitesimal guide section

Figure 4

Effect of using a linear slot profile

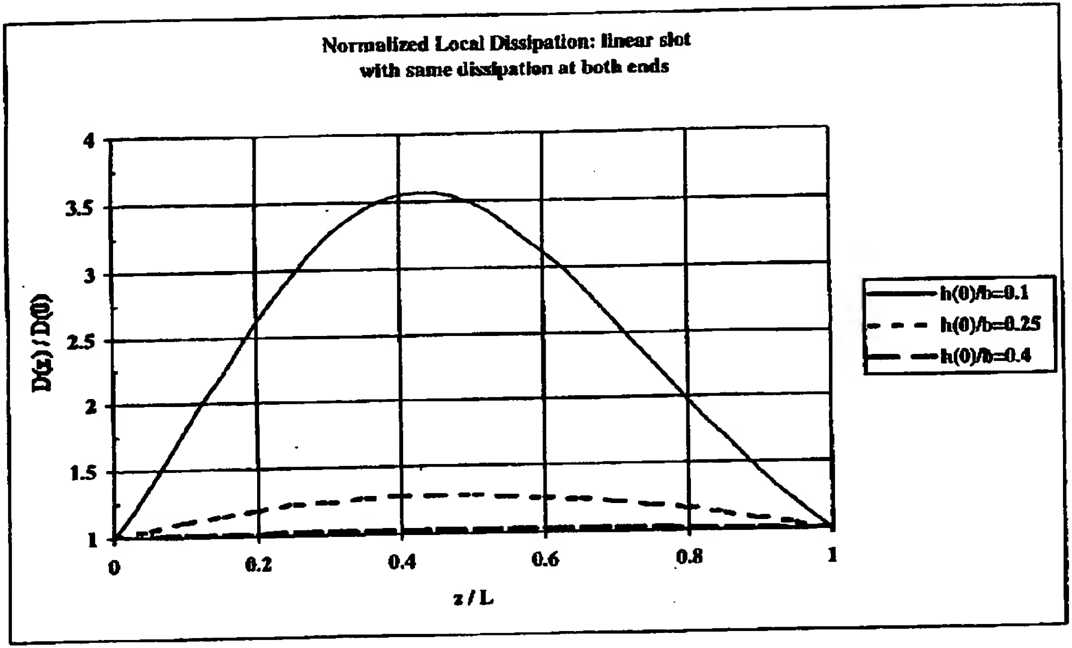
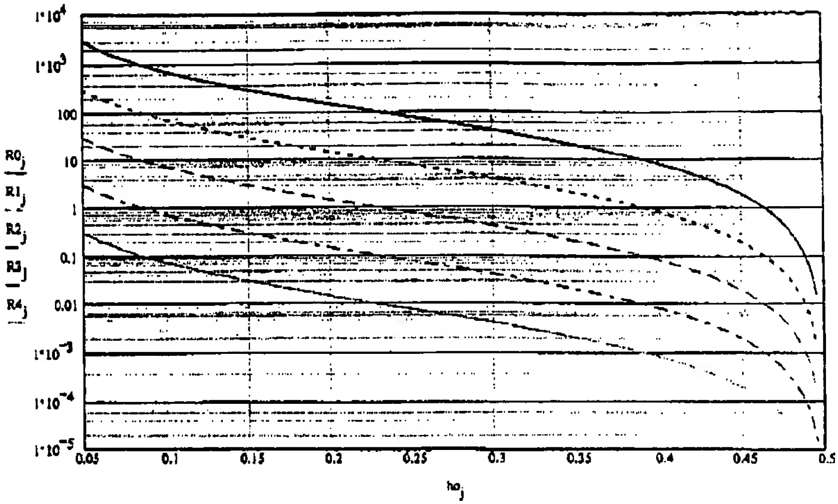


Figure 5

Linear Slot Dissipation Profile as a Function of Starting Slot Height



These are plots of the range of curved-slot-compensated waveguide as a function of ho/b, the ratio of the starting slot height to the guide breadth. Curves are drawn for different values of ε r"t in meters. The values of ε r"t plotted are listed below. The curves drop to lower values as ε r"t increases

Figure 6

$b = 0.072$ guide breadth in m

$f = 2.45 \cdot 10^9$ frequency in Hz

$\sin(\pi \cdot \min)^2 = 0.024$

$$\varepsilon rt = \begin{bmatrix} 5 \cdot 10^{-6} \\ 5 \cdot 10^{-5} \\ 5 \cdot 10^{-4} \\ 5 \cdot 10^{-3} \\ 0.05 \end{bmatrix}$$

Now calculate the shape of a slot curve for a given er"t and hc/b

$\varepsilon rt := 10^{-4}$ enter web imaginary dielectric constant times thickness in meters

$N := 1000$ enter number of data points in a slot curve plot

$j := 0..N-1$ set up iteration parameter for range plots

$homin := .15$ enter starting ratio of h/b

$$zmax := \frac{b\cdot\left(\frac{1}{\sin(\pi\cdot homin)^2}-1\right)}{2\cdot\omega\cdot Z\cdot\varepsilon o\cdot\varepsilon rt}$$

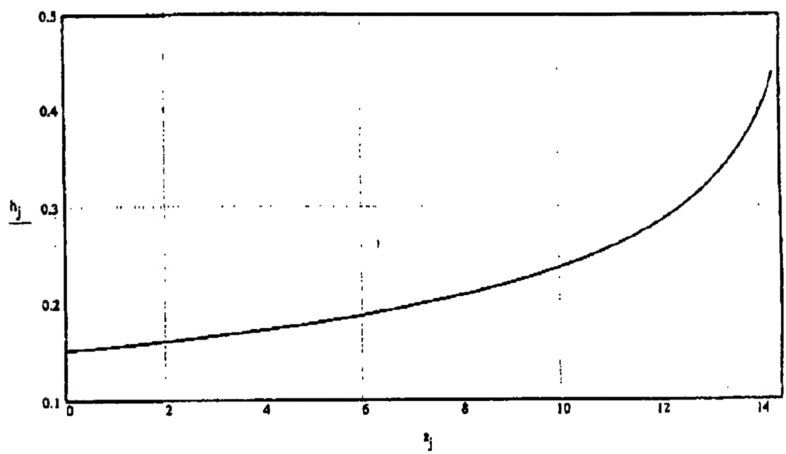
calculate maximum value of compensated z

$$z_j := .99\cdot zmax\cdot\frac{j}{N-1}$$

generate values for slot height plots

$$h_j := \left(\frac{1}{\pi}\right)\cdot asin\left[\left(\frac{1}{\sin(\pi\cdot homin)^2}-2\cdot\omega\cdot Z\cdot\varepsilon o\cdot\frac{\varepsilon rt}{b}\cdot z_j\right)^{\frac{-1}{2}}\right]$$

calculate slot height values normalized to b as a function of z



This is a plot of height of the slot divided by the guide breadth as a function of guide length in meters

Figure. 7

$\varepsilon rt = 1\cdot10^{-4}$ web imaginary dielectric constant times thickness (m)

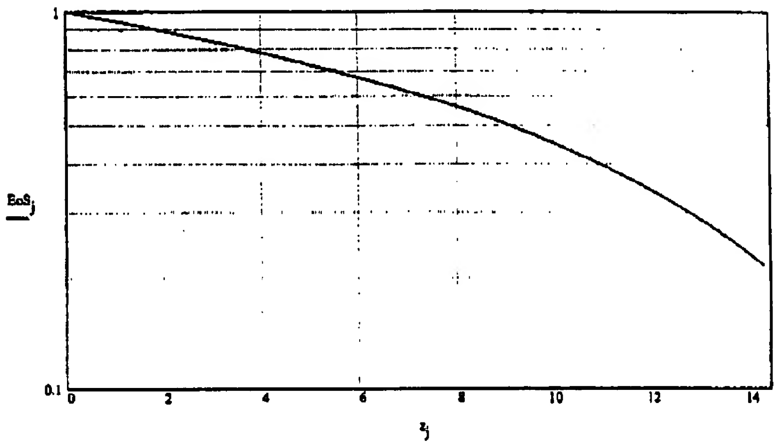
$homin = 0.15$ initial h/b

$zmax = 14.443$ range of compensation in meters

Calculate the ratio of the E field intensity at the guide center to its initial value as a function of z for the same parameters as in the slot shape curve just above.

$$EoS_j := \left(1 - 2\cdot\omega\cdot Z\cdot\varepsilon o\cdot\frac{\varepsilon rt}{b}\cdot z_j\cdot\sin(\pi\cdot homin)^2\right)$$

calculate the ratio of Eo squared to Eoo to squared as a function of z



This is a plot of the relative center guide field intensity versus guide length for an IMS optimum compensated slotted waveguide. The z axis is in meter and y axis is the intensity is ratioed to its value at z=0.

Figure 8

$\varepsilon rt = 1\cdot 10^{-4}$ web imaginary dielectric constant times thickness (m)

$homin = 0.15$ initial h/b

$zmax = 14.443$ range of compensation in meters

$M := 4$ enter number of web runs

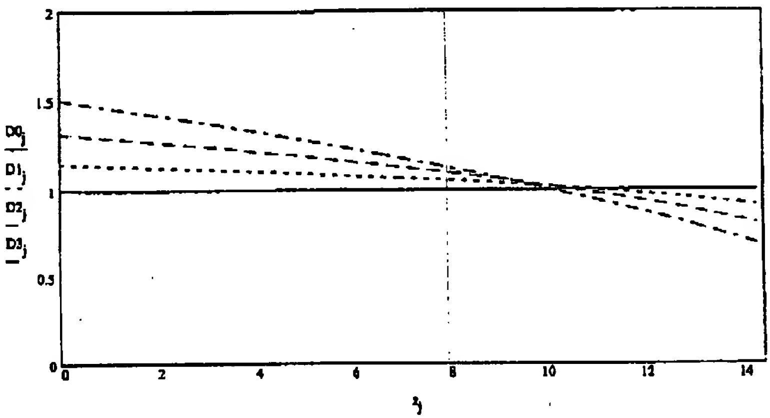
$R := 1.5$ enter maximum ratio of εrt operation to εrt designed

$m := 0..M-1$ iteration parameter

$r_m := R^{\frac{m}{M-1}}$ calculate the values of the ratio of the actual εrt to the designed εrt

$$D0_j := r_0 \cdot \left(1 - 2\cdot\omega\cdot Z\cdot\varepsilon o\cdot\frac{\varepsilon rt}{b}\cdot z_j\cdot\sin(\pi\cdot homin)^2\right)^{r_0-1} \qquad D1_j := r_1 \cdot \left(1 - 2\cdot\omega\cdot Z\cdot\varepsilon o\cdot\frac{\varepsilon rt}{b}\cdot z_j\cdot\sin(\pi\cdot homin)^2\right)^{r_1-1}$$

$$D2_j := r_2 \cdot \left(1 - 2\cdot\omega\cdot Z\cdot\varepsilon o\cdot\frac{\varepsilon rt}{b}\cdot z_j\cdot\sin(\pi\cdot homin)^2\right)^{r_2-1} \qquad D3_j := r_3 \cdot \left(1 - 2\cdot\omega\cdot Z\cdot\varepsilon o\cdot\frac{\varepsilon rt}{b}\cdot z_j\cdot\sin(\pi\cdot homin)^2\right)^{r_3-1}$$



These are plots of the web heat dissipation relative to the heat dissipation at z=0 in the designed waveguide as a function of waveguide length in meters. Different curves have differeent ratios of εrt operating to εrt designed. The actual ratios are listed below as r

Figure 9

$\varepsilon rt = 1\cdot10^{-4}$ designed web imaginary dielectric constant times thickness (m)

$$r = \begin{bmatrix} 1 \\ 1.145 \\ 1.31 \\ 1.5 \end{bmatrix}$$

$zmax = 14.443$ range of compensation in meters

$homin = 0.15$ initial h/b

Two Serpentine Microwave Applicator Configurations: (a) Short at Termination End; (b) Dummy Load at Termination End.

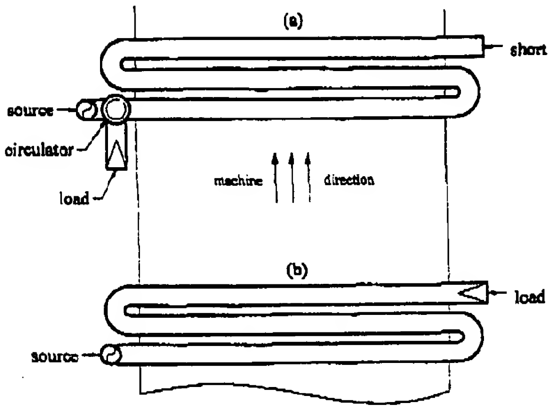


FIGURE 10

Definition of Slot (and Paper)
Location within the Waveguide. The cross-machine coordinate is z and h(z) is the local elevation of the slot above the bottom of the waveguide. The overall active cross-machine length is L..

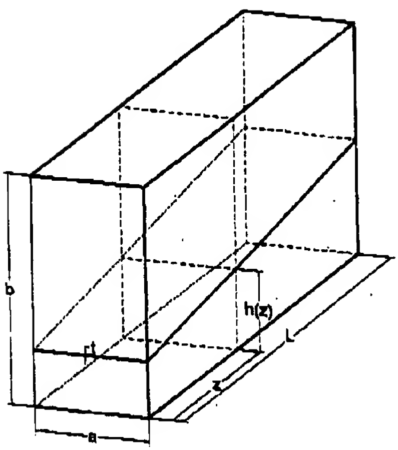
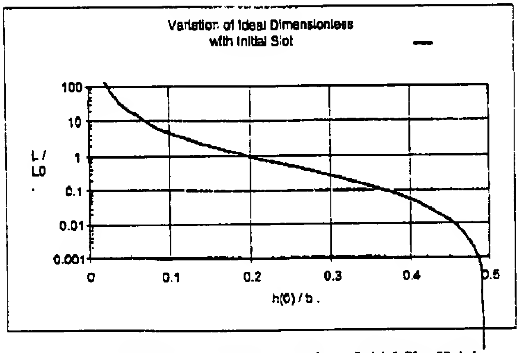
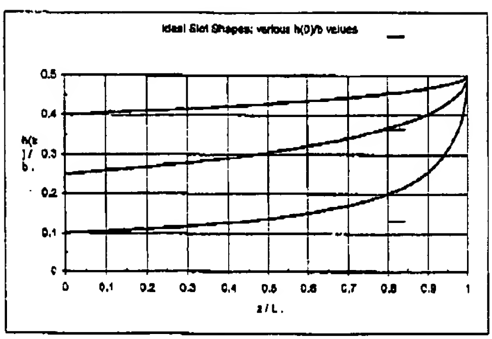


FIGURE 11



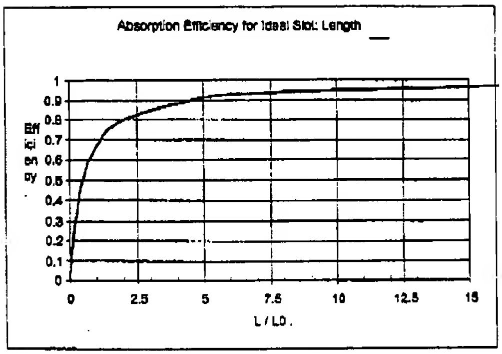
Ideal Dimensionless Length vs. Initial Slot Height.

FIGURE 12



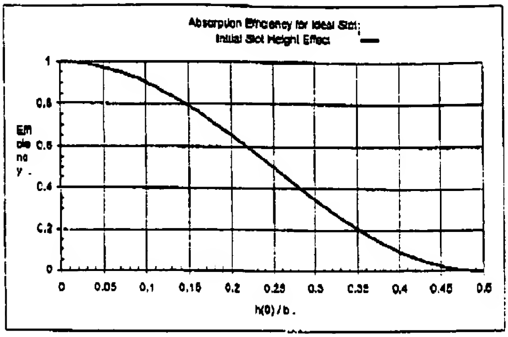
Ideal Slot Shapes foh(0)/b = 0.1, 0.25, 0.4.

FIGURE 13



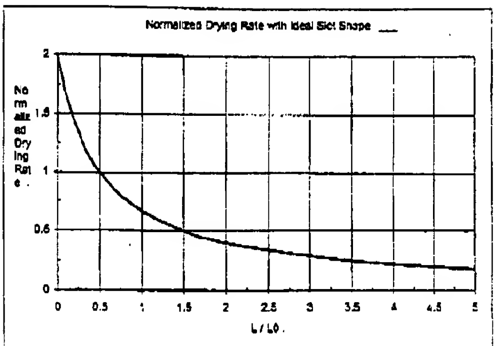
Efficiency vs. Ideal Dimensionless Length.

FIGURE 14



Efficiency (at Ideal Length) vs. Initial Height.

FIGURE 15



Normalized Drying Rate for Ideal Length.

FIGURE 16

The slot height profile, h(z), which gives uniform drying depends on the paper basis weight and its moisture content, $\varepsilon_r''t$.

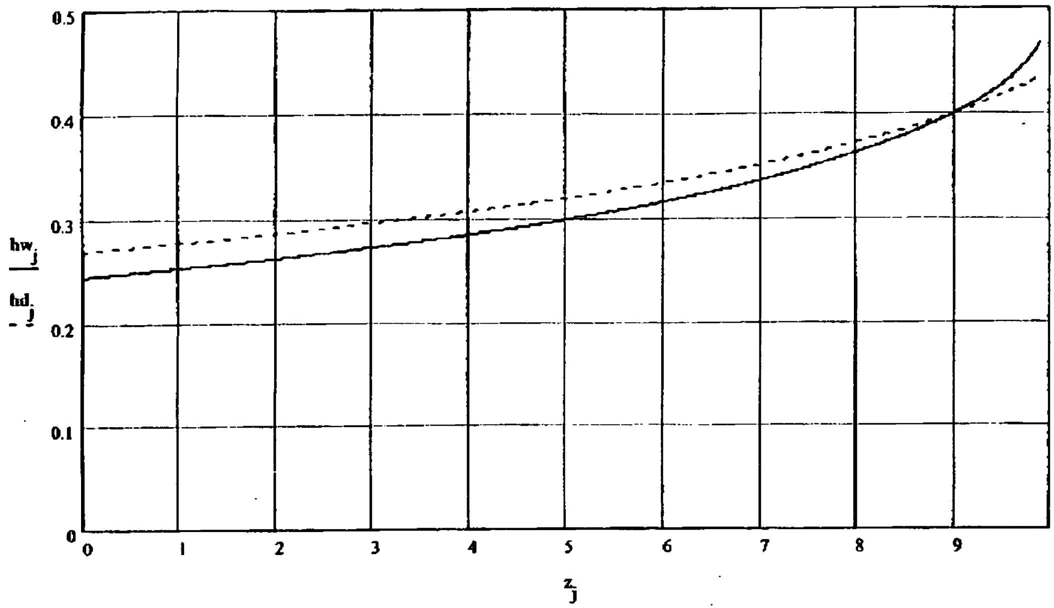
The optimal slot profile is

$$h(z) = (b/\pi)\sin^{-1}[(1/\sin^2(\pi h_o/b) - 2Z\omega\varepsilon_o\varepsilon_r''tz/b)^{-1/2}]$$

where h_o represents the slot height at the source side of the web and z is the distance along the waveguide (CD).

Fig. 17

Optimal Slot Profiles



Plots of the optimal slot height divided by the waveguide height as a function of distance in meters from a microwave source at 2.45 GHz in an S-band waveguide. The solid line is designed for a 200 g/m² board at 10% moisture,whereas the dotted line is for 7% moisture.

Fig. 18

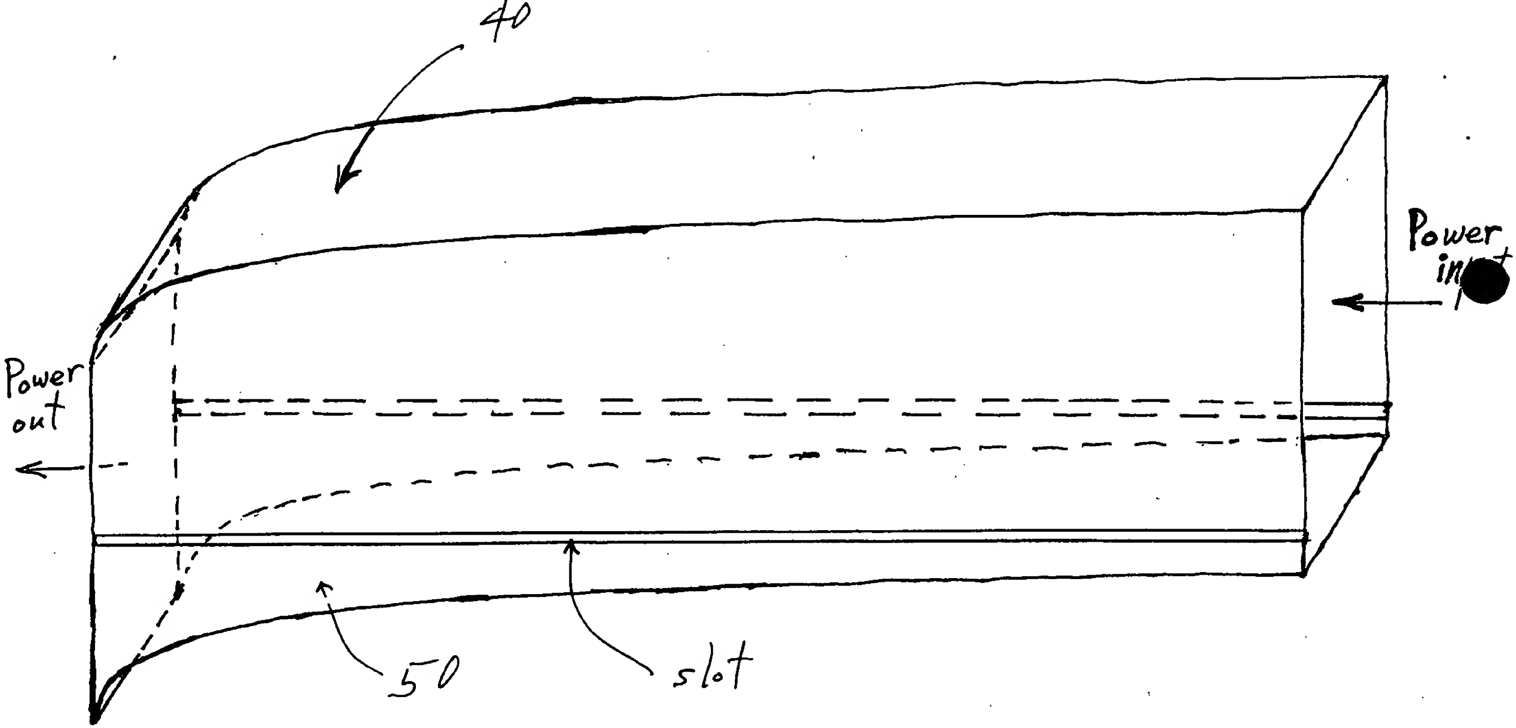
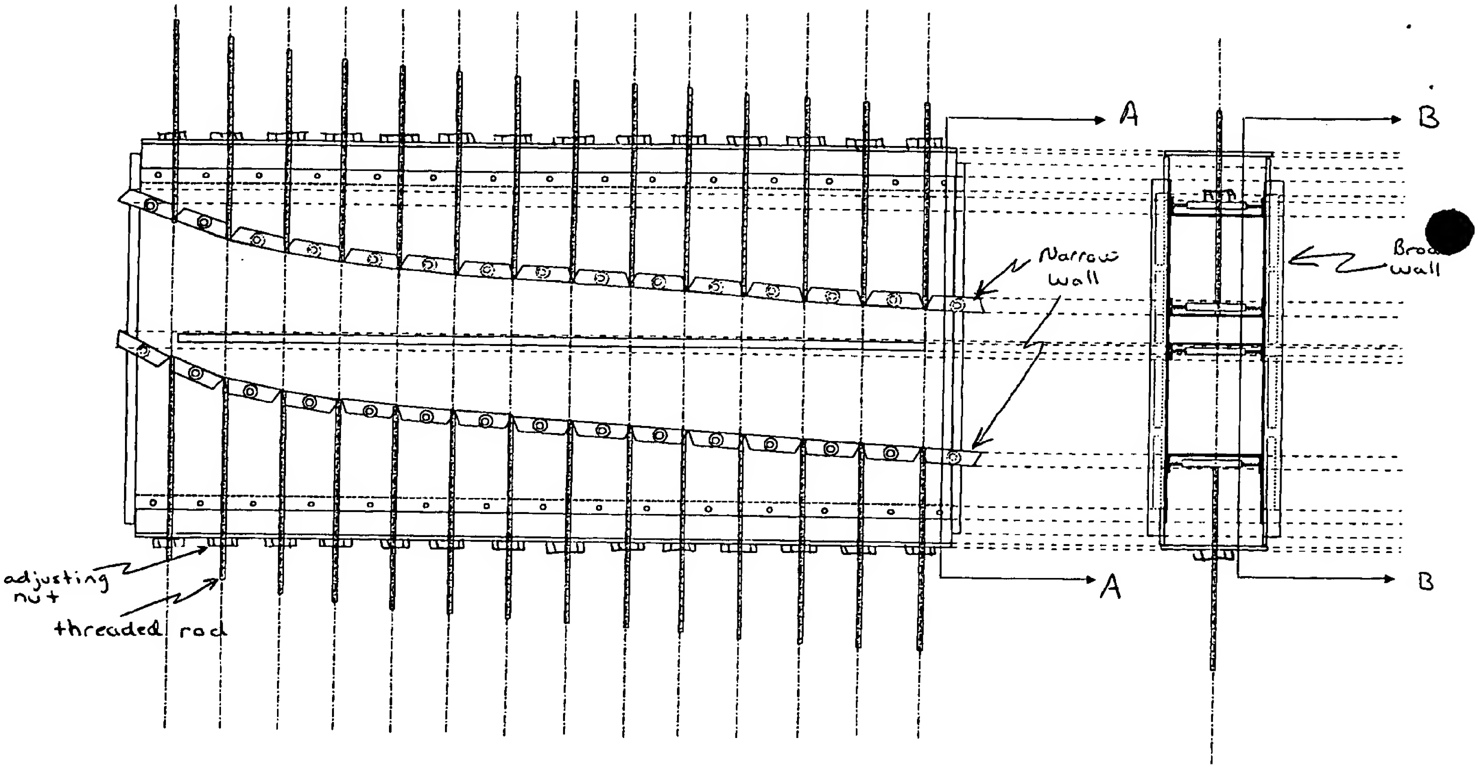


FIGURE 19

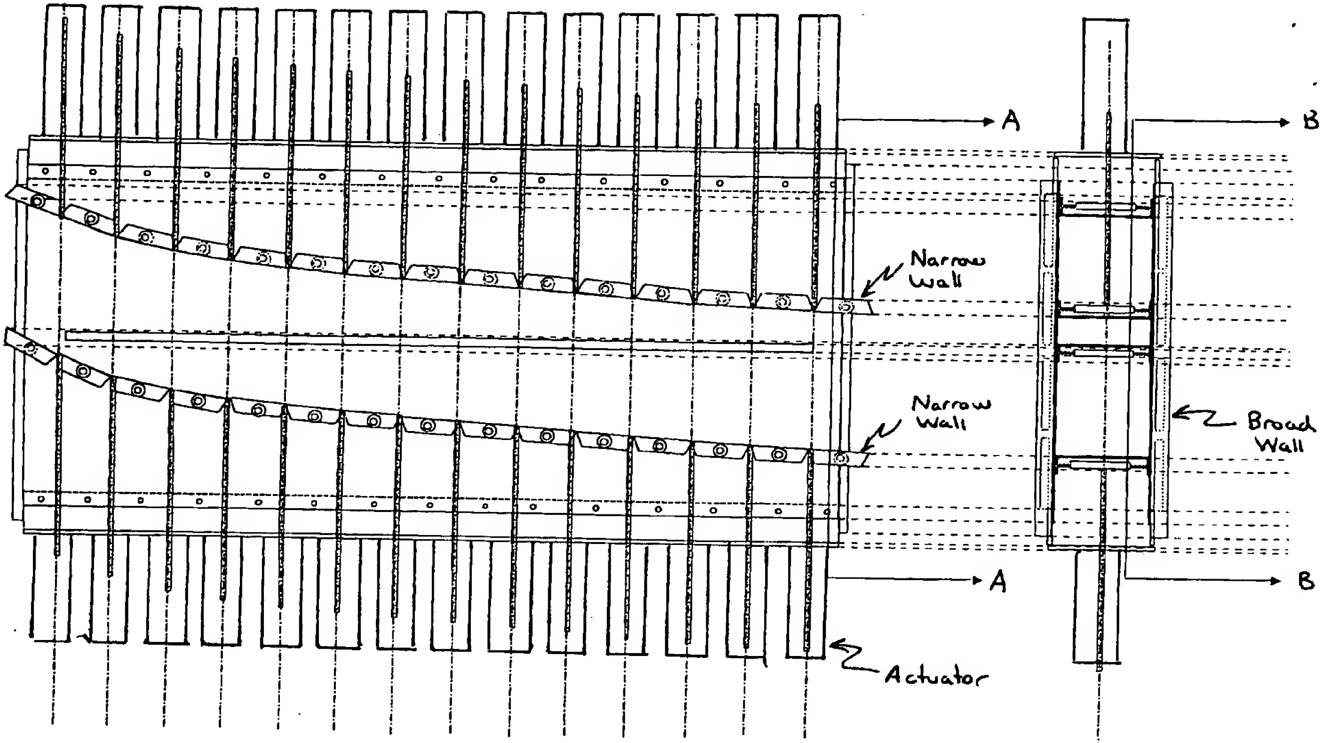


SIDE VIEW - SECTION B-B

END VIEW
SECTION A-A

Manually Adjusted Variable Waveguide

Fig. 20



SIDE VIEW
SECTION B-B

END VIEW
SECTION A-A

Automatically Adjusted Variable Waveguide

FIG 21